Abstracting TRIZ

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Abstract

In this article, the authors explore the common space and the potential synergies between Knowledge Management and TRIZ. To understand this, it is useful to take a practical approach: The Information-Space model (abstraction, codification and diffusion) from Max Boisot is used to situate TRIZ and find commonalities between both disciplines.

The authors focus mainly on a selected set of tools that TRIZ is composed of: Su-field analysis, SLP, Contradictions, ARIZ, Function Modeling, Laws & Trends, Functional Modeling and the TRIZ ‘knowledge database of effects’. Ariz 85c will be compared with the Social Learning Curve (=SLC), a dynamic flow of information and knowledge creation in I-space.

Which are the representation models these tools use to represent knowledge? The main features such as, representation; perceptive and abstracted levels for problem formulation and solution directions of the tools will be discussed.

Keywords

Knowledge Management, abstraction, codification, diffusion, I-space, SLC

1 MAX’S BOISOT I SPACE

Although it would be interesting to explore all possible directions that Knowledge Management has taken and the various changes it has made or to map all definitions of knowledge and even information and data; we tend to use the I space model created by Max Boisot. In accordance with Nonaka and Takeuchi [21]; Boisot proposes a similar model of knowledge asset development. His model consists of three axes as shown in figure 1.

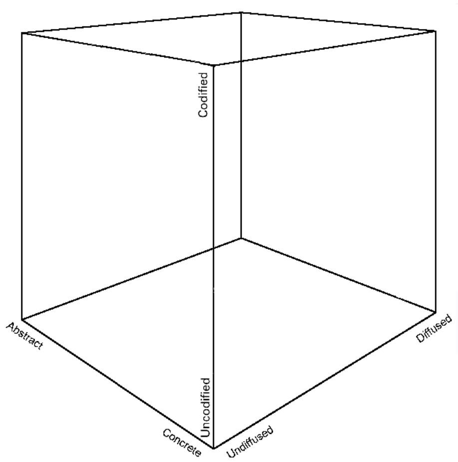

Figure 1: Information-space

The first ax describes the diffusion of the information among a population often named the dimension of information sharing. If the knowledge only exists within a small group we call this undiffused, if the information is available to everybody, it is called diffused. For instance, the news on the intranet of a company will be shared to everybody thus can hardly be called undiffused. However the detailed financial results of the company will most probably be calculated by the accountant alone and not by everybody in the company. Not all of the financial information will be shared.

The better information is codified and the more structured that information is, the higher the percentage of the population to which this information will become accessible. However, Boisot's model introduces 2 extra dimensions.

1.1 Perceiving as coding

Codification varies from tacit or uncodified to explicit knowledge or codified. The term tacit knowledge originates from the British philosopher Polanyi [22]. Polanyi points out that we cannot describe a familiar face in detail. Thus most what we know cannot be stated. Tacit knowledge can be described as “that what is between the ears”. It could be misunderstood that one could simply extract all tacit knowledge from somebody and transfer it to explicit.

The act of assigning phenomena to categories once these have been created is known as coding. Coding is about selection, perception and categorization. Once codified, standards often create a lock-in effect that over time becomes irreversible. Coding is extracting information from data. Coding tries to limit the number of different states a system can be in. Codification articulates and helps to distinguish the categories that we draw upon to make sense of our world. Thus the process of codification gives form to phenomena to reduce the amount of data. A complex object, such as a typewriter, may be perceived with different levels of coding.

1. **Contemplating**: low in structure, high in information , high complexity
2. **Naming** a typewriter: classification
3. **Interacting** with the object: identify its constituent elements, how they interact, differentiation and integration, lower degree of complexity, lower info and the first 2, operative working. Coding is the answer to: “how many ways are there to know the object/system?"

1.2 Conceiving as abstraction

The third ax is varying from abstraction to concrete.

By treating things that are different as if they were similar, reduces the number of categories that we need to draw upon in order to apprehend a phenomenon. Abstraction is another way to decrease the amount of data. While concreteness is build up with perceptual and local knowledge – highly concrete experiences, abstractness is constructed by means of conceptual and non-local knowledge – abstract thought

Mark that conceptual and perceptual categories interfuse. Perception is never free of a conceptual element and perceptual coding always invokes prior theoretical knowledge (the result of successful earlier generalizations)

The axes of abstraction moves from manipulating images ;and other objects of experience (iconic coding); towards signs. Further up in the scale of abstraction, we start operating with symbols that have been drained from any perceptual content. Semiotics gives us three useful points on such a scale:

1. **icon**,
2. **sign** and
3. **symbol**.

Abstraction is closely related to codification as they are both extended forms of data reduction. By structuring the phenomena, that have already been codified, the number of categories is even reduced further. However, abstraction essentially differs from codification; the process of codification focuses on giving form to phenomena, while the process of abstraction zooms out to the structures above these phenomena.

If a perceptual object exhibits f binary attributes, the probability distribution will require 2^f numbers to specify. If the attributes are grouped in s classes only $s2^{f/s}$ numbers will be needed.

The following table summarizes the different axes and helps to articulate, refine and share the perceptions of a company's knowledge assets can be distributed in I-space.

Position on Scale	Codification: Is the knowledge:	Abstraction Is the knowledge:	Diffusion Is the knowledge:
High	Easily captured in figures and formulate? Does it lead itself to standardization and automation?	Generally applicable to all agents whatever sector they operate in? Is it heavily science based?	Readily available to all agents who wish to make use of it?
Medium	Describable in words and diagrams? Can it be readily understood by others from documents and written instructions alone?	Applicable to agents within a few sectors only? Does it need to be adapted to the context in which it is applied?	Available to only a few agents or only a few sectors?
Low	Hard to articulate? Is it easier to show someone than to tell them about it?	Limited to a single sector and application within that sector? Does it need extensive adaptation to the context in which it is applied?	Available to only one or two agents within a single sector?

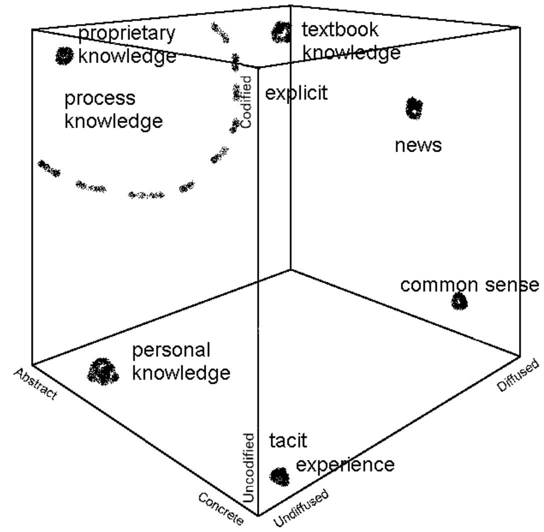

Figure 2: knowledge types and process knowledge in I-space [1].

The three dimensions of codification, abstraction and diffusion together form the Information-Space or I-space as seen in figure 2. I-space helps to understand the different flows of different kinds of information.

2 ABSTRACTING TRIZ

How Altshuller came up with the idea of abstraction and codification is unknown to the authors. Originating from VAVE in the early 1980's S. Litvin, V. Gerassimov, B. Zlotin and others acting as engineering managers gradually used and improved function modeling often called Function Cost Analysis while learning TRIZ from Altshuller. [14] [11]

It is worth mentioning that in the beginning of VAVE the ladder of abstraction was used [7].

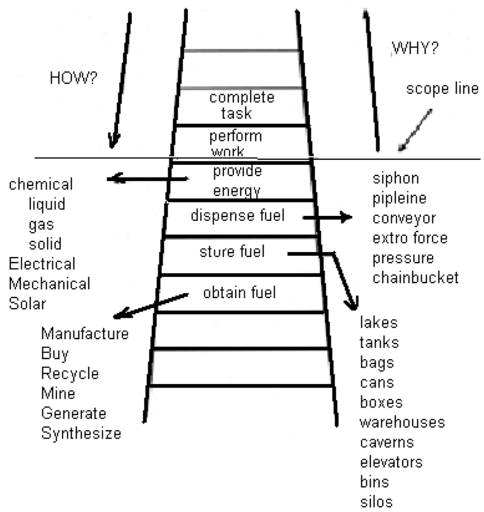

Figure 3: Ladder of abstraction, basic function of a Fueling system [17].

Climbing up the ladder means asking the "why" question and moving down means asking the "how" question. A similar technique was developed by De Bono called "Concept Fan" [8] [13]. This jumping back and forth between can be considered as a creative process in which moving is more important than evaluating the alternatives.

From a TRIZ point of view we could state that TRIZ wants to diffuse through abstracting and codification.

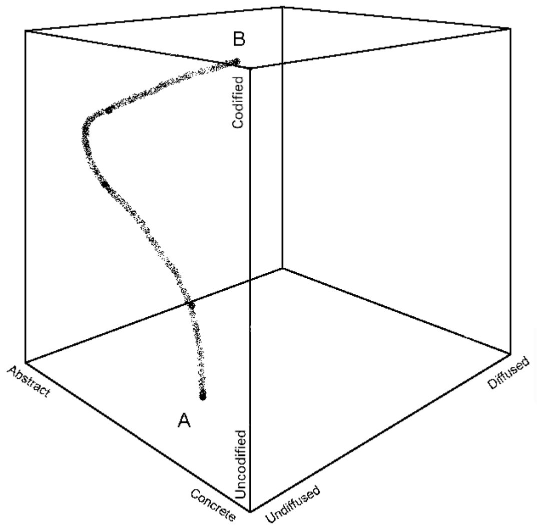

Figure 4: Diffusion curve in I-space [9].

Boisot hypothesizes that codification and abstraction together facilitate the diffusion of information and that they reinforce each other. This hypothesis can be visualized in the I-Space [see figure 2]. For instance, the curve in *figure 2* moving from point A to point B indicates 'that the more codified and abstract an item of information becomes, then, other things being equal, the larger the percentage of a given population it will be able to reach in a given period of time' [9]. Yet this level of abstraction is considered to be one of its undiffused reasons [4] which seems to contradict Boisot's hypothesis. Abstracting in our view can be confusing for some people.

Boisot considers this curve to be static, 'depicting a function relationship between codification, abstraction, and diffusion at a single instant in time' [9].

TRIZ strives to expand the 'body of knowledge' to different disciplines, sectors and domains. Solving a problem should be expanded to different 'directions' or otherwise should be taken from a diffused range of information sources.

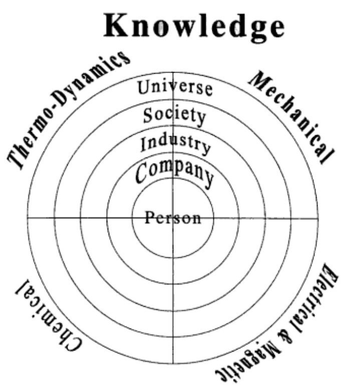

Figure 5: the expansion of knowledge [3].

In our opinion one of the strong aspects of TRIZ is not to solve all problems but to abstract it somehow and solve the abstracted or general problem and then somehow go back down the abstraction to make it more concrete. In this sense TRIZ can be considered an abstracted approach to problem solving, similar to mathematics where a squared equation is solved abstracted, for example. [3]

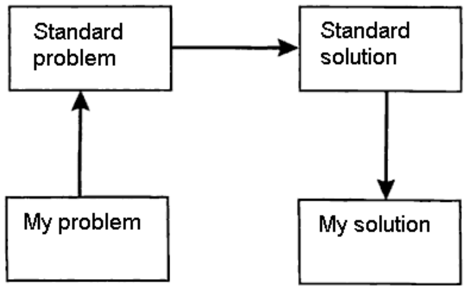

Figure 6: Organizing and using general knowledge [3].

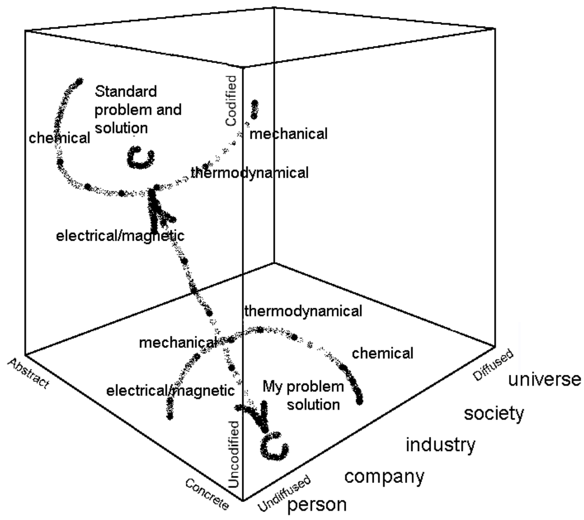

Figure 7: figure 5 and 6 in I-space.

The generic or generalized level in which a technical contradiction is written is nothing more than an application of organizing and using general knowledge [3].

Function modeling based on the SVO principle or functional modeling as the cause effect diagrams, like Ideation has developed; contain an iconic to sign-like abstraction. For more info on the different types of function modeling see [12].

The "Small Little People" or "Miniature Dwarfs" modeling technique allows even more signs and abstraction. Unique for this technique is that also a sort of feature transfer is used: a person's awareness is added to unaware objects.

The authors find that the highest level of symbolic representation of problems and solutions is given in the form of the Su-field analysis. A chemical like representation is used to describe and visualize a general problem associated with the 76 standards.

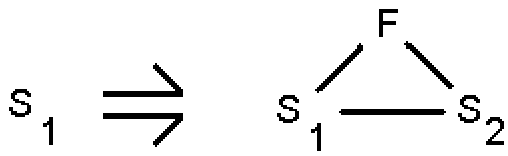

Figure 8: Su-field transition [6].

At the same time a form of codification exists. Think about how the Su-field symbols are used to represent the abstracted problem and on the other hand to codify different solution directions. But also seeing the "logging" of the 'knowledge database of effects' as a potential resource is unknown in other disciples as far as we know. The codification of the 40 Inventive Principles is another good example of how TRIZ copes with data, abstracted from several thousands of patents.

Another good example of defining a level of codification and abstraction is found in the laws or patterns of evolution.

The third example would be the level of codification that was used by Altshuller and his followers. Altshuller analyzed between 1964 and 1974 patents through codification of level of inventiveness. After reviewing 200.000 patents abstracts, he selected 40.000 as the representative base for inventive solutions [3].

GEN:3 TRIZ+ approach is another good example of maximizing the abstraction of a highly function codified problem.

The approach of Alex Pinyayev's Functional Clues focuses on a mini-problem function in coded solution space [5] [20]. In our former article on Function Modeling Issues we also suggest to use generalized functions to reach a higher level of abstraction and thus a higher potential solution scope [12].

These examples show that TRIZ can be situated in I-space at a fairly high level of abstraction and codification. The diffusion factor is somewhat unclear to the authors integrating as much as knowledge as possible but yet is rather unknown.

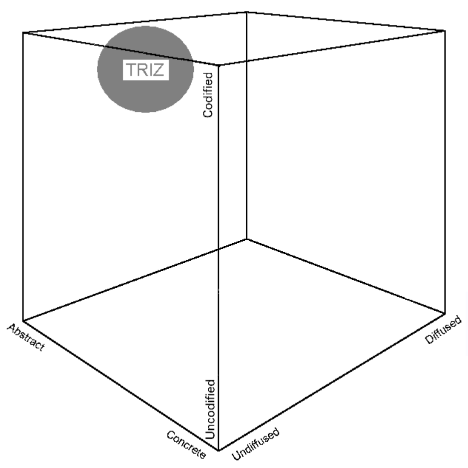

Figure 9: Situating TRIZ in I space

It appears that TRIZ could be situated as shown in figure 7 as a static point of knowledge. However, Boisot remarks that the I-Space can also be used more dynamically.

3 THE SOCIAL LEARNING CYCLE

Boisot proposes a "Social Learning Cycle" (SLC) which uses the I-Space to model the dynamic flow of knowledge through a series of six phases:

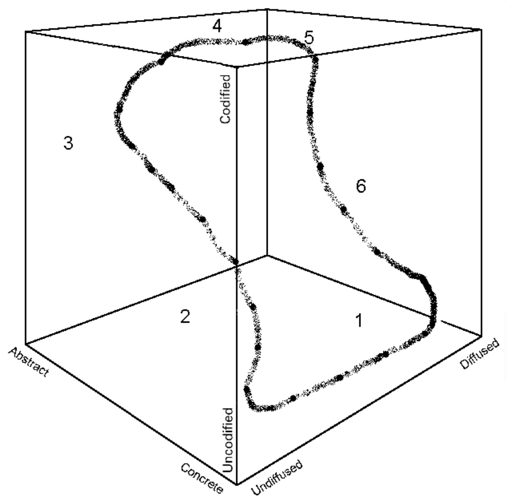

Figure 10: SLC

1. *Scanning:* insights are gained from generally available (diffused) data. Scanning patterns such as data into unique or idiosyncratic insights evolve towards undiffused population.

2. *Problem-Solving:* problems are solved giving structure and coherence to these insights (knowledge becomes 'codified').

3. *Abstraction:* the newly codified insights are generalized to a wide range of situations

4. *Diffusion:* the new insights are shared with a target population in a codified and abstract form (knowledge becomes 'diffused')

5. *Absorption:* the newly codified insights are applied to a variety of situations producing new learning experiences (knowledge is absorbed and produces learned behavior and so becomes 'uncodified', or 'tacit')

6. *Impacting:* abstract knowledge becomes embedded in concrete practices, for example in artifacts, rules or behavior patterns (knowledge becomes 'concrete')

Boisot makes an interesting interpretation of the laws of thermodynamics in relation to knowledge assets. He considers highly abstract, highly codified and undiffused knowledge assets, as the most ordered and so they have the lowest rate of entropy production and therefore the maximum potential for performing value-adding work. Knowledge assets that find themselves at the opposite extreme of the I-Space (least abstract, least codified and most diffused) have the highest level of entropy production and, therefore, have the least potential for performing useful value-adding work.

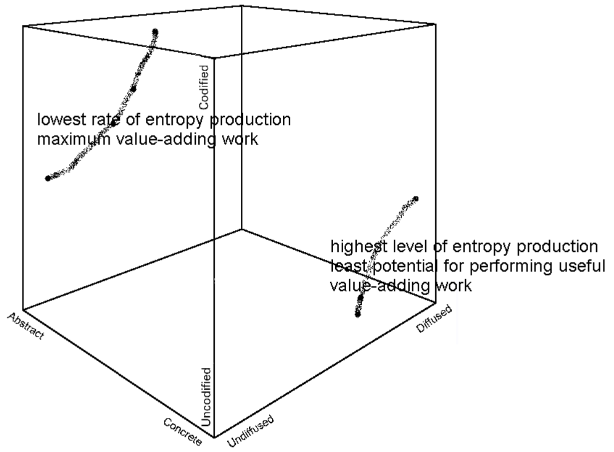

Figure 11: Minimum and maximum entropy in I-space

Any organization should focus on reaching the lowest level of entropy however, the dynamics of the SLC imply that they can never stay in this region, but are constantly pulled away in a continual cycle of innovation and application. In order to have any practical value knowledge must be diffused under those who do not possess it. This thermodynamic analogy points out the elusive and dynamic nature of knowledge. It seems that what is happening is a continous cycle in which *data* is filtered to produce meaningful *information* and this information is then abstracted and codified to produce useful *knowledge*. As the knowledge is applied in diverse situations it produces new experiences in an uncodified form which produces the data for a new cycle of knowledge creation. What seems clear from both Boisot's model and that of Nonaka & Takeuchi is that the process of growing and developing knowledge assets within organizations is always changing. In this sense a Darwinian view of organizations sheds light on what is happening in the Industry. Organizations are like living organisms that must constantly adapt to their environment. This means that companies will have to adapt and evolve all the time by going through the SLC cycle time and time. The rate at which this cycle operates will vary from one sector to another, so that in rapidly evolving sectors new knowledge is being created and applied in fast succession, while in some more established sectors, the cycle time of innovation is much slower. (Knowledge becomes more 'abstract')

4 ARIZ AND SLC

Situating ARIZ 85c [15] in the SLC it is clear that ARIZ is a step-by-step algorithm to scan, codify and abstract a problem to such an extent that it can be readily solved.

Step 1.1: exists of defining the technical contradictions in the mini-problem thus codifying it.

Step 1.2: proceeds in codification by pointing out the tool and the product.

Step 1.3: abstracts the problem by using signs and symbols.

Step 1.4 through 1.6: Intensifies the conflict.

Step 1.7: suggests to use the inventive standards, highly coded and abstracted solution directions.

Step 2.1 through step 2.3: re-examines and codifies the problem but also suggests to perform a new scan of the systems resources.

Step 3.1 through 3.4: Write down the IFR-1 formulation, with X object at macro level: recoding the problem. Three first parts of the ARIZ reformulate the initial problem.

Souchov states that ARIZ aims to remove our mental inertia and give birth to new breakthrough solution concepts which might be totally different from already known solutions [15]. New concepts appear, which sometimes can be difficult to express with appropriate words thus indicating a tacit or uncodified form.

Step 3.5 Composing IFR-2, we obtain a new problem, now at the physical level. It is necessary to solve this physical problem.

Step 3.6: Try using Inventive standards eg. Using a abstracted and codified solution form.

Step 4.1: Reaching the highest level of abstraction

Step 4.2 and 4.3. Stepping back from IFR and using resources (voids, electrical fields,..)

Step 5.1 until 5.4: using the abstracted codified knowledge from TRIZ.

Step 6 is about problem reformulation and Step 7 focus on using physical contradictions and solving them, thus returning back to 1.1 etc.

Step 8.3 however tries to generalize the found solution to a higher degree to use it for something else. In this case, generalization points more to diffusion than abstraction.

Step 9.2 examines the expansion of the abstracted and codified knowledge

In figure 10 several problem solving steps of ARIZ85c are displayed. Note that the solution itself can be abstract or concrete, codified or uncodified.

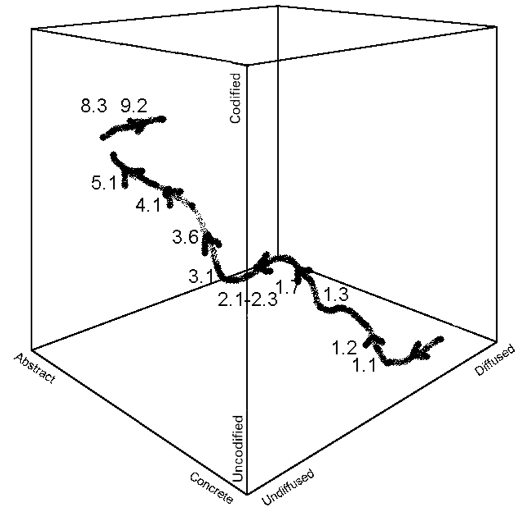

Figure 12: ARIZ steps in SLC

5 KM CHARACTERISTICS OF TRIZ TOOLS

TRIZ houses many tools and methods, only several we have evaluated and mapped in Table 2. We looked specifically at the representation, perceptual inputs: Visual(V), Olfactic (O), Tactile(T), Auditory(A), Gustatic (G), Linguistic(L), and abstraction for problem formulation as well as for the solution directions as provided by TRIZ.

We can conclude that all the tools have a strong linguistic aspect. (See table 2 at the end)

6 SUMMARY.

We have presented Max Boisot's model of I-space to relate to the techniques and databases TRIZ provides.

We view TRIZ more like a proto-science, a science in birth, because it uses icons and signs as compared to the symbols from mathematics, maximum codified databases of knowledge; all helping in an seemingly unpredictable but repetitive approach solving problems. The primary function of abstracting and codifying is to decrease the amount of data, which is clearly the success of TRIZ.

We see TRIZ being highly abstracted and codified but more undiffused than diffused knowledge.

A correlation between the dynamic social learning curve and ARIZ was made to show how close SLC and ARIZ really are. SLC adds in comparison to TRIZ, the diffusion aspect inside an organisation.

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	Problem			Solution		
Name	**Representation**	**Percep-tual**	**Abstrac-tion level**	**Representation**	**Percep-tual**	**Abstrac-tion level**
Su-field	through visual symbolic aid	VL	symbolic	visual symbolic standards textual examples	VL	symbolic
Small little people (SLP)	visual aid using signs, the living aspect (interactions)	VOTAGL	sign	visual aid, the living aspect (interactions), find the X-guy	VOTAGL	sign
Contradictions	linguistic, graph with good bad, bad good	VL	no	principles as text and drawings, textual examples	L	no
Function modeling (Technoptimiser based)	visual aid, map of super and subsystems	VL	sign	visual aid (Sicafus)	L	sign
Laws of Engineering Systems Evolution	evolutionairy	L	no	none	none	no
Functional modeling (Innovation Workbench)	visual & linguistic approach	VL	sign	linguistic (Find a way how to...)	L	no

Table 2: Categorisation of problem formulation and solution direction in terms of perceptive and abstracted representations.